Space Weather Technical Forecast

Issued on Sunday, 31 October 2021 at 01:20 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: CME arrival expected day 1 (31st) with G1/G2 Minor to Moderate storms and isolated G3 Strong Storms. G3 Watch issued.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was low, with a number of C-class flares from AR2891 Dac/Beta in the northeast, but has been gradually declining. AR2887 Csi/Beta in the southwest has also continued to gradually simplify and dissipate. AR2892 Bxo/Beta is the only other sunspot on the disc, in the northwest, and is both small and simple. No Earth-directed CMEs have been observed in available imagery in the last 24 hours.

Solar Wind / Geomagnetic Activity: The solar wind speed, as measured by DSCOVR at L1 remained at background, but gradually increased from near 300km/s to 380 km/s. Density values also increased from average levels to peak 38ppcc, before return back to average levels at 30/1900 UTC. The interplanetary magnetic field (IMF), Bt, was weak at first but increased to moderate levels of 8-12nT from around 30/1600 UTC. The north-south component, Bz also increased from background levels to be predominately negative (southward) from 30/1930 UTC with peak value -11nT. Phi angle was in a predominantly negative direction (towards the Sun), but rotated to positive after 30/1900 UTC. These parameters indicate a CME passing Earth, but notably weaker than the anticipated CME arrival, and likely from the passing of a CME which from a filament eruption in the southeast on 26/2000 UTC, with the anticipated CME yet to arrive. Resultant geomagnetic activity was Quiet (Kp0-2), but increased to Active 30/2100-2400 UTC.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured by GOES-16 was at S1/ Minor Storm values at first, peaking at 21 pfu, before declining to be below the S1 level from 30/2200 UTC. The 100 MeV Protons were at active thresholds (above 1pfu) until 30/0440 UTC. The high energy electron flux (greater than 2 MeV) was predominantly at background levels with the associated 24-hour electron fluence below the Active (1e8 integrated pfu) threshold, with 1.2e6 integrated pfu recorded at 31/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar Activity is forecast is forecast to be Low over the next 4 days with a slight chance of further M-class flares, primarily from AR2891.

Solar Wind / Geomagnetic Activity: A notable CME from an X-class flare eruption on the 28th is still forecast to arrive at Earth early on the 31st, a little later than originally anticipated. Geomagnetic activity is expected to increase to give Minor to Moderate geomagnetic storms (G1/G2 Kp5-6), with a likelihood of isolated G3/Strong storms (Kp7). Geomagnetic activity is then expected to gradually subside during the day 2 into day 3 (1st and 2nd) with an eventual return to Quiet to Unsettled, with a chance of Active intervals (Kp2-4). A further solar wind enhancement is possible day 4 (3rd) due to the arrival of the fast wind of CH16, becoming Unsettled to Active with a chance of G1/Minor Storms.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to be below the S1 minor storm level, decreasing to background through the period.

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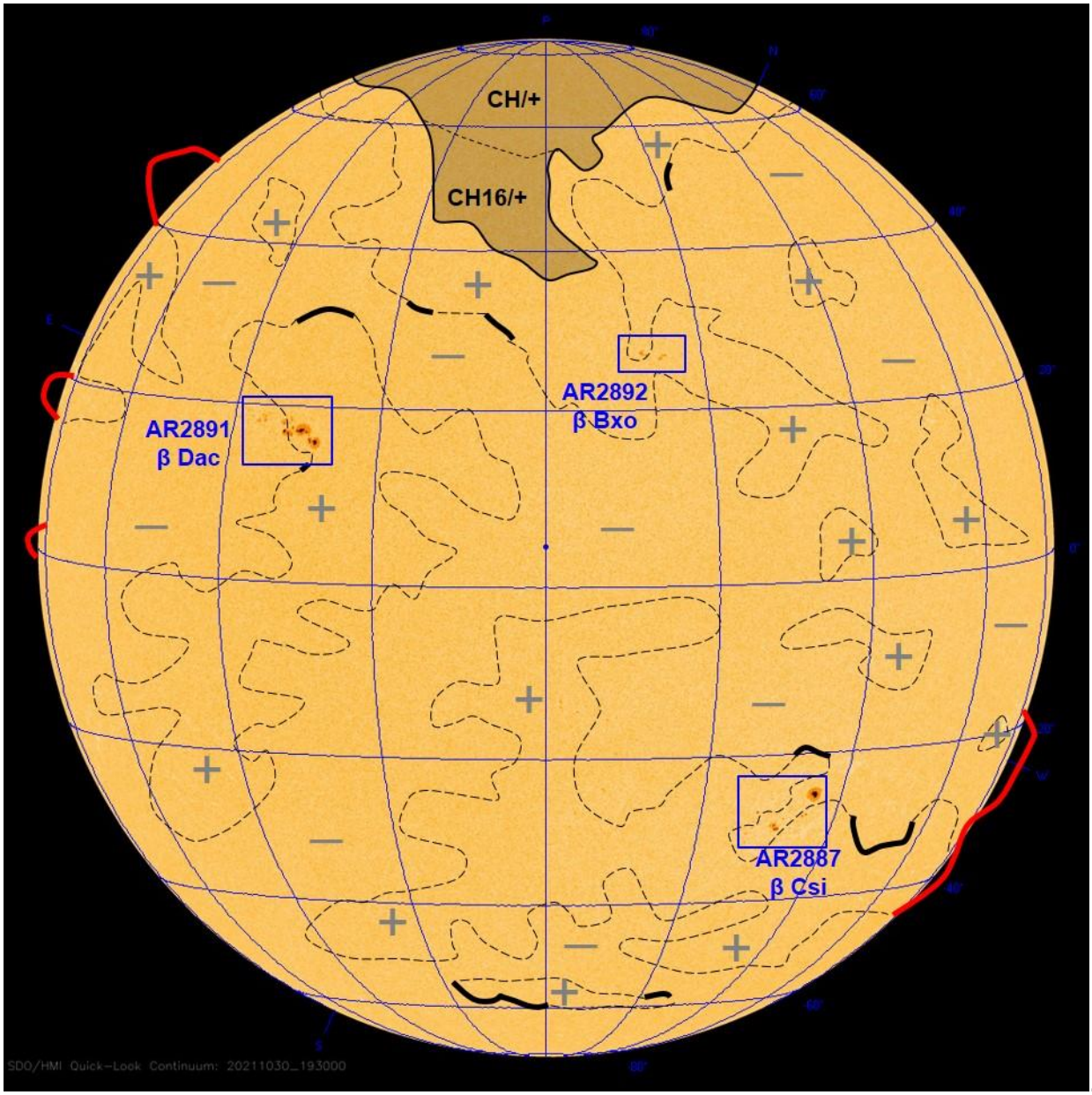
The high energy electron flux (greater than 2 MeV) is forecast to remain mostly at background levels between day 1 (31st), but with a risk of exceeding the Active level (1e3pfu) threshold at times later by day 2 as geomagnetic activity following the expected CME arrival subsides. The associated 24 hour fluence is expected to remain largely below the Active (1e8 integrated pfu) level, but with a slight chance of exceeding this threshold by day 3 (2nd).

Figure 1. Solar Analysis Valid 30/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A large full-halo CME was observed leaving the sun in coronagraph imagery following the X-class flare from AR2887 on the 28th at 1535UTC. This feature was analysed as Earth-directed was expected 30/1200-2400 UTC, but has yet to arrive. This is still expected in the coming hours. A further smaller and slower CME that occurred on the 26/2000 UTC has likely given a glancing impact on passing Earth in the previous hours.

Solar winds are currently at background, but increasing with moderately strong IMF, due to the recent weak CME arrival. The arrival of the faster CME is expected to bring a sudden increase in solar winds, perhaps to 500-600 km/s in the coming hours, with solar winds then gradually easing to background as the CME subsides day 2 onward (1st Nov). A further enhancement is then possible day 4 from the arrival of the fast wind of positive polarity coronal hole 16 which is a southern extension of the northern polar crown.

Geomagnetic activity is forecast to soon increase from Unsettled to Active to give Minor to Moderate Geomagnetic storms (G1/G2) with the CME arrival, and a likelihood of isolated G3/Strong storms (Kp7). Geomagnetic activity is then expected to gradually subside day 2 (1st) and into day 3 (2nd) with eventual return to Quiet to Unsettled levels, with a chance of Active intervals (Kp2-4). There is then a chance of G1/Minor storm intervals, perhaps day 3 (2nd) but more likely day 4 (3rd) from any fast wind arrival from CH16.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	90	60	20	30
Strong	G3	No	60	10	1	1
Severe	G4	No	10	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

CME-202110-041	28/10/2021 15:35	1E	20S	1200	52	28/10/2021 18:44
CME-202110-040	26/10/2021 20:00	20E	15S	440	21	27/10/2021 04:47

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Figure 2: ENLIL showing expected CME arrival with ensemble

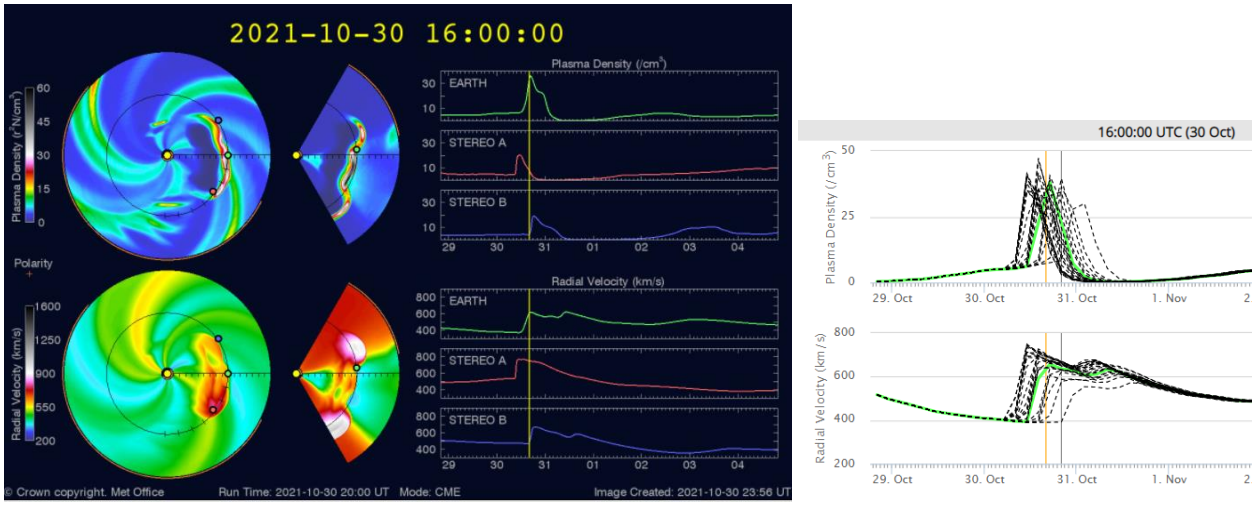

Figure 3: L1 Observed Solar winds and magnetic field

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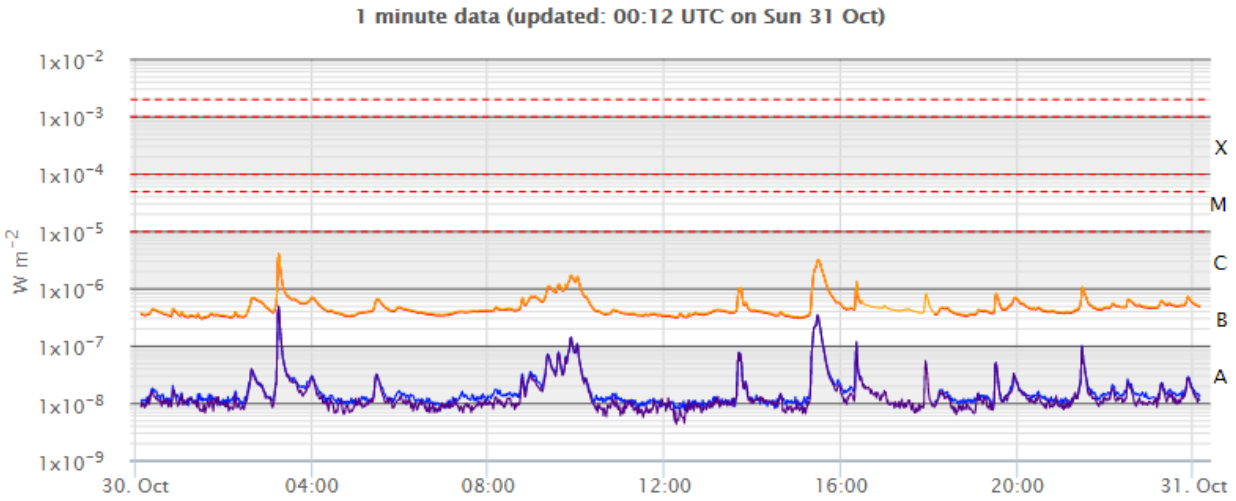
Radio Blackouts - X-Ray Flares:

Solar Activity is currently Low, with three sunspot containing active regions, and a number of C-class flares observed, primarily from AR2891 Dac/Beta. This region has been simplifying a little and has reduced in size in the last 24 hours, but still has the potential for M-class flares. AR2887 Csi/Beta has also continued to decay, since its X1-flare on the 28th. The final sunspot is AR2892 Bxo/Beta, a small and simple region in the centre disc. There is one active region expected to soon rotate onto the disc, during day 1 (31st) in the northeast.

Solar Active is expected to remain at Low levels, with a slight chance of increasing to Moderate.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	No	20	20	20	20
Very Active	R3 to R5 X Class	No	2	2	2	2

Figure 4: GOES-16 X-ray Flux



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Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is currently just below S1/Minor storm levels, having declined from S1 through the last 24 hours. Whilst likely staying below this level, with a gradual trend towards background through the period, there is a chance of further brief increases above S1 on day 1

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	20	2	2	2
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 5: GOES 16 Proton Flux

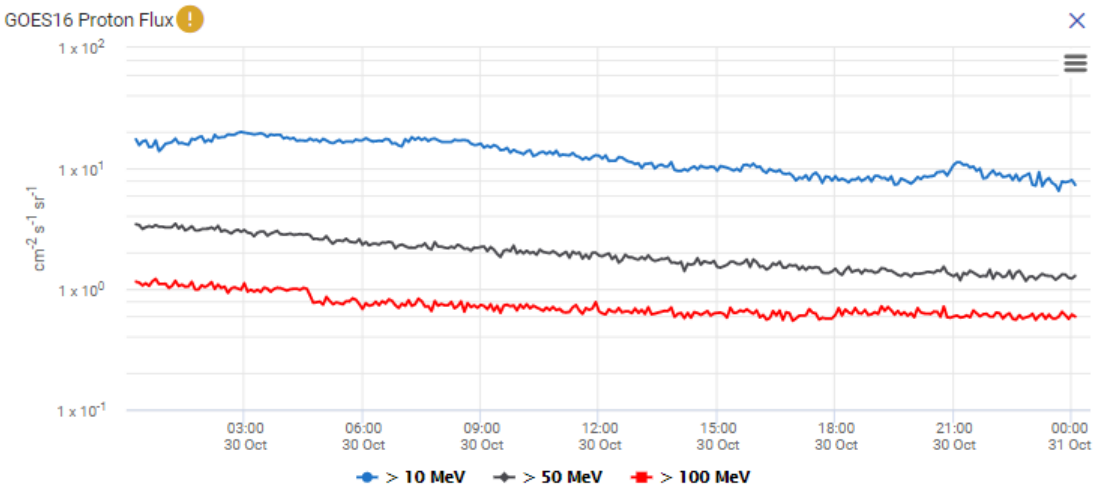
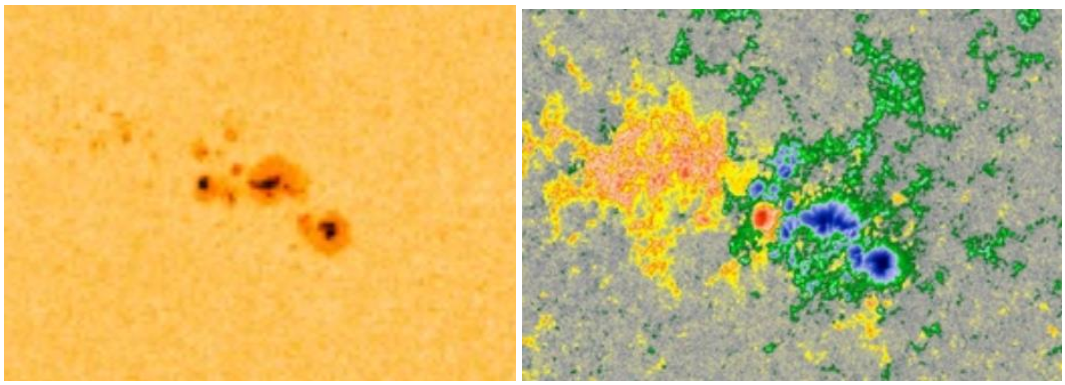


Figure 6: SDO: Intensitygram and Magnetogram of AR2891



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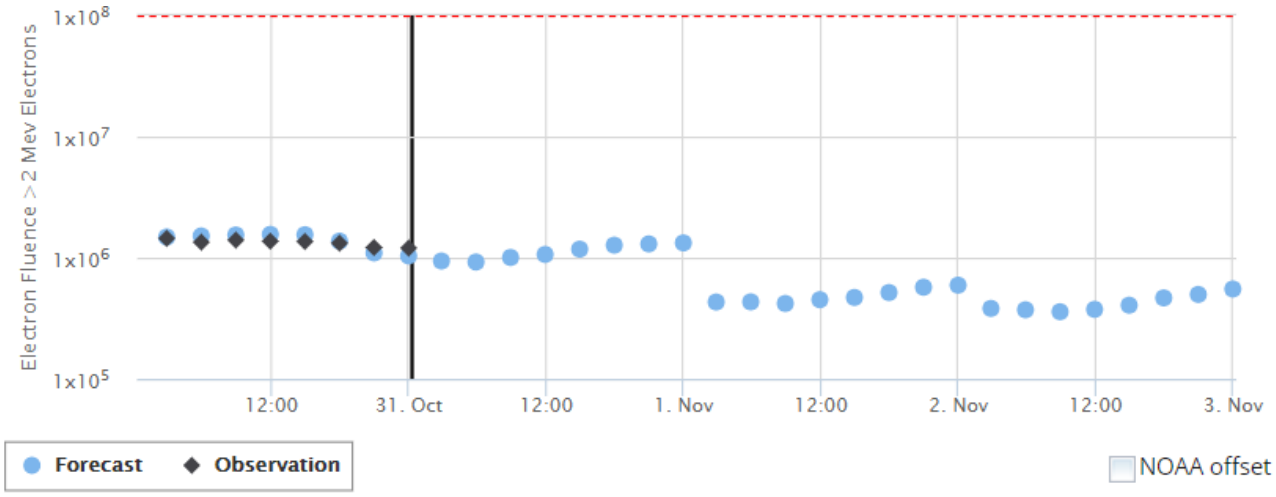
High Energy Electrons Event (≥ 2MeV):

The high energy electron flux (greater than 2 MeV) as observed by GOES-16 at GEO is currently at background levels and expected to persist at this or moderate levels for much of the period. The still anticipated, but late arrival of the CME on day 1 (31st) has the potential to inject electrons into the Van Allen radiation belts. As geomagnetic activity subsides day 3 (1st) onward, the observed electron flux has the potential to increase to above the alert threshold (1000 pfu) although confidence is low. This will give a chance of reaching the Active fluence threshold (1e8 integrated pfu) from late day 2 onward (1st). REFM doesn't take account of the expected CME arrival, so whilst a good guide to current background conditions, will be of limited value when this arrives.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	5	30	30	20
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 7: GOES-16 >2MeV Electron Fluence with REFM



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